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Please Return To
Engineering Staff

ENG-M9 - 836

Chief, Procurement Division, OL
ATTN: Contracts Administration Branch

23 SEP 1959

Chief, Engineering Staff, OC

Contract [redacted] 50X1

1. [redacted], under the subject contract, is fabricating 16 Signal Actuate Device prototypes. 50X1

2. Under the terms of this task the government shall furnish to the contractor one each electronic switching circuit sub-assembly for incorporation in each of the prototypes fabricated under this task. Sub-assemblies, serial numbers 124 through 140, were hand carried to the contractor on 4 September 1959. The project engineer on this task is [redacted] 50X1

[redacted] 50X1
Acting

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file T.O.K

PROJECT DISCUSSION WITH CUSTOMER ENGINEER

November 5-6, 1959

Project #163 (TEMA)
Project #160 (15 TEM)
Project #183 (15 SAD)

1. The two purposes of this discussion were (1) to resolve apparent differences in observations in connection with operation of SAD from electronic circuitry other than that supplied originally under Project 74B, and (2) to arrive at details of application of a desiccant to the SAD Project #183 based on work now being done in connection with application of a desiccant to TEM-A under Project #163.

2. Bi-stable multivibrator for operation of SAD. It was pointed out that the electronics package requirements had been changed so that we should not expect the same type of operation as the specification to which we were working originally. The new requirements are that the unit should not trigger from a single pulse but from a succession of pulses between 6 and 10. Our specification was that the unit should operate from a single pulse. We had found in our tests that the new unit would operate from a ragged pulse such as striking two wires together but apparently did not operate from a single "clean" pulse which was to be expected of course under the new specification.

3. It was found on tests here after this explanation was made that if a succession of pulses such as 25 per second was fed to the unit it would operate. No study was made while the customer engineer was here to determine just how many pulses did produce operation of the unit. The results of the test described next indicate that we should determine this.

with a 7.1 volt supply

4. Tests made on November 6 showed that the energization to the SAD solenoid occurs in two steps, the first of which applies approximately 3 volts to the resistor-condenser combination and the solenoid. This is later followed by the full pulse of 5.7 volts. The time for this first plateau is the same as the distance between pulses.

5. The only logical explanation we see for this operation is that one pulse does not put the proper bias on the base of the output transistor to cause full switching action and that a later pulse then gives full switching action.

6. This type of operation is very poor for the resistor-condenser type of operation of the solenoid. The first plateau will partially charge the condenser but not operate the solenoid. The energization level is too low to provide sufficient amperes turns to operate the solenoid although the length of the pulse may be several times that required to operate the solenoid when it has proper voltage. In this particular case, the time is approximately 3 times that required.

7. This pulse then charges the condenser appreciably so that when the later full height comes through there will not be any appreciable current developed through the solenoid. The amount of useable energy delivered to the solenoid is rather unpredicable.

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8. The result is to raise the voltage requirement for the solenoid above that required with full switching of the output solenoid in one step as was done with the previous electronic circuitry.

was considered by avion, however, it was left out of their schematic

9. It was noted that the circuit provided by the vendor for his electronic package did not show any resistor-condenser combination in connection with the solenoid. This may mean that the effect of the resistor-condenser combination upon the voltage which would be supplied to the solenoid was not considered.

10. It was found here that when the electronic system was triggered the SAD unit we had recently supplied did not work. Examination of the circuit shows that in addition to the resistance of the Emitter-Collector portion of the transistor circuit there has been a 100 ohm resistor introduced in this circuit.

11. Calculation shows that this will reduce the energization from the line voltage by a minimum of 27%. The word minimum is used because this resistor is also the return path for the Emitter-Collector circuit of the transistor used in this package for resetting the multivibrator and releasing the solenoid. There will be an additional drop through this resistor, therefore, caused by the steady state leakage. This value will be quite low at normal temperature but might increase radically when the temperature goes up.

12. It was pointed out by our customer engineer that two other units worked satisfactorily with this electronics and this one did not, and the suggestion made that there must be something wrong with this solenoid. However, tests showed that this solenoid operated satisfactorily with 3.9 volts on the solenoid directly and 4.9 volts on the resistor-condenser-solenoid combination at room temperature. Apparently, the other units must have had a lower operating voltage than this one although this one is lower than would ordinarily have been required.

This statement incorrect the tests showed voltages required as 4 Volts and 5.7 volts respectively RF

13. There was a considerable discussion of factors leading to variations in solenoid operation. [redacted] pointed out approximately 10 things in the manufactur 50X1 a solenoid which might cause variations in operation of a particular solenoid. There are others. Some of these are:

A. Variation in actual diameter of the wire used for winding a solenoid.

B. Variation in the magnetic permeability of a particular piece of iron used.

C. Slight variation in the air gap of the solenoid at time of pick-up.

D. Variation in thickness of springs used for the spring portion of this device (1/10 thousandth difference can mean as much as 30% variation in spring pressure).

E. Variation in adjustment of contacts such as opening and compression when contacts are closed.

F. Changes in friction of the various parts operated by the solenoid and by the plunger in its housing as well.

G. Slight movement in the point of attack of the contact driving part upon the contacts themselves.

H. Tolerances in the actual stiffness of the contact spring material even when the thickness does not change.

I. Variations in the eccentricity of the solenoid plunger in its upper air gap. (This causes large variation in side pull and consequently in the friction, and resulting required ampere turns.)

J. Differences in mounting of the hack operating arm with respect to the axis of the plunger are very critical.

14. In the manufacture of very large solenoids, these factors can be more readily controlled than in small ones. In small ones, even the control of many dimensions to a very few ten-thousandths of an inch permits a measurable variation in most of the factors outlined.

15. There is no attempt made in manufacturing solenoids of this type to keep all solenoids at a definite operating point. Neither is it possible (because of economic and time considerations) to build a large batch of solenoids and select out of these only the ones which are close to one operating value.

16. Consequently, a particular solenoid is calculated and built and a study made of its characteristics. Then some practical estimates are made of the likelihood of other solenoids having different characteristics.

17. After this first solenoid has been built, the ones built for use will in most cases be given a different winding resistance to bring their operating point and force possibilities (as shown by the tests on the first model) within the force requirements of the load.

18. If a particular solenoid made later turns out to have a much better operating voltage than is actually needed, it is not altered to have its characteristics come out the same as other solenoids but is left as having a larger margin for operation than the average would have.

19. It appears likely that the vendor built his circuit around a solenoid which is better than would be required for the circuit it was originally designed to work with. Consequently, the introduction of the 100 ohms in series with the solenoid he was testing did not cause trouble even though the operation may have been somewhat marginal.

20. We do not have data on the actual operating point of the original SAD which was apparently used in designing this electronic package. It passed a 4.5 volt test which seemed to be all that was necessary for its use in connection with the electronic package designed for it originally.

21. At the suggestion of our customer engineer, tests will be made to determine what voltage must be supplied by the vendor to the resistor-condenser-solenoid combination for operation. Incidental observations on the operation of the electronic package will also be submitted .

22. It should be noted that when we are operating a resistor-condenser-solenoid combination the transient solution is rather complex and changes in any of

the parameters do not produce obvious and readily determined effects. A complete or definitive classical mathematical solution of the apparent transient problem is made impractical by ordinary means because of (1) variation in inductance with energization. (2) similar variation of inductance with air gap. (3) inertia effects changing the load-air gap plot. (4) changes in the force required curve. (5) non-linear changes in the transistor part of the circuit, and probably others.

23. It was noted that the unit supplied to us has 13 milliamperes stand by current--compared to less than 2 ma for the unit supplied under 74B.

24. It was found that the SAD unit had been damaged. The hack wire was badly bent near its support and was not adjusted properly to cause the balance wheel to hack on the proper screw when the solenoid was released. The back-up support for this hack wire had been broken off and was now attached near the support by a glob of some type of adhesive and was not in position to engage the hack wire itself but was down near the pillar plate of the watch assembly. We also found a spot of the adhesive on the balance wheel.

25. This total hack assembly was replaced and the defective one given to our customer engineer for his further investigation. It will then be returned to us for replacement of springs and for use in a later unit which will be supplied on Project #183.

26. [redacted] requested that we supply him 5 copies of the up-to-date circuits on TEM (Project #160) and SAD (Project #183) as he feel his are not the latest after addition of testing wires to 160 and addition of sensitivity adjustment to 183. We should similarily supply 5 copies of the latest circuit drawing on TEM-A as (Project #163) as some wires have been added to this as well.

27. It was suggested that we cement the gaskets used for closing up TEM and SAD. It was pointed out the disadvantage of this is that you do not have as smooth a surface to apply the gasket to when you use cement as you do when there is no cement and, therefore, have a tendency to get a poorer seal. This will be investigated further for some type of light cement which can be applied more evenly.

28. It was suggested that "Seel Skrews" be used for the two screws on the back of the TEM-A unit. This will be investigated as to feasibility and used if possible.

29. It is agreed that we will not use potting on the electronic package of the 163 unit unless vibration tests show that it is not possible to hold the units properly without it. Potting is being omitted to facilitate any repairs or replacements which might later be needed on the electronic circuit board.

30. Desiccant application. Our customer engineer was shown a unit we have made up using a small desiccant package supplied by Culligan to Bell & Howell for aerial cameras and a commercial unit just obtained from a company in Connecticut. The Culligan unit was decided upon.

31. The general system plan is to have a desiccant package which is mounted in a threaded hex assembly screwed into the back end of the TEM-A. This hex unit has a window in it thru which a blue blotting paper indicator can be observed. In case moisture is detected this total unit would be removed

and the TEM-A purged with dry nitrogen as described below:

32. An adaptor would be screwed into the threaded hole used for the desiccant package. A small bottle of nitrogen at approximately 1500 lbs. pressure is used. This unit is similar in size and shape to the carbon dioxide units used in seltzer bottles, but has a threaded end.

33. The adaptor would have a hollow piercing pin so that when the nitrogen bottle is screwed down into the thread the piercing pin would pierce the end of the nitrogen bottle releasing the pressure.

34. The threads of the adapter receiving the bottle would have a semifluid type compound so that the 1500 lbs. pressure would not be exhausted along the threads of the adapter to the outside of the case.

35. The adapter itself would have a very small thread (48 per inch). The one shown our customer engineer has a cross hole from the piercing pin out to these threads. From the point of exit of this hole the threads on the adapter were truncated about .009" to provide in effect a long capillary from this point to the inside of the unit. This is to reduce the velocity of the nitrogen which would enter the unit.

36. It was found quite difficult to make these small threads accurately enough to provide a tight capillary, so the nitrogen did enter the unit more rapidly than desired.

37. An alternative solution is to use a ball and seat to seal off this pressure. The ball would be held into the seat by a screw without a spring. There would be a small hole leading from a point along this screw into the TEM unit.

38. After the nitrogen bottle had been pierced and the pressure exerted upon this ball assembly the screw described would be backed off very slightly until the 1500 lb. pressure had been relieved slowly into the TEM unit and then opened fully, giving a final charge to the unit.

39. During this charging period a screw is removed from the front end of the TEM-A unit to permit egress of the moist atmosphere as dry nitrogen is being introduced.

40. If the indicator show the presence of considerable moisture it would be desirable to charge the unit by using more than one of the bottles of nitrogen. Each bottle of nitrogen provides several volumes of gas compared to the space inside the TEM-A unit.

41. It has been found that there is very little cooling from the expansion of this gas since there is no change of state. Therefore, a simpler arrangement is being tried which will involve the use of a very fine tube (a hypodermic needle is contemplated) extending into the unit from the piercing pin. It is anticipated that this will provide sufficient restriction to the initial inrush of nitrogen to avoid blasting effects and building up too high pressure inside the unit with possible rupture of a gasket.

42. It was agreed that altho the fine threads originally used would not now be required for the capillary effect no change would be made on the present unit, thereby saving considerable time and effort. (The fine thread also works out better for the SAD unit with the restrictions placed on it 11-11-59)

43. It would be undesirable for the case of the unit to be entirely loose from the unit itself when replacing the desiccant unit with the adapter. We will, therefore, provide two screws for holding the assembly together in addition to this larger hex assembly.

44. Desiccant unit - SAD. To avoid changing cases and other parts on SAD, and still use the present planned desiccant package for the TEM-A it was agreed a bushing assembly will be fastened to the case to space out the hex unit far enough that it will not interfere with the electronic package on the inside. Our customer engineer is going to give us more definite information on the electronic package so that we may determine the length required in this bushing.

45. Information 11-11-59 directs that (1) we use an indicator only for SAD in place of a desiccant package, to save space, (2) we do not use space inside the case of SAD, (3) use a bushing maximum extension from case of $\frac{1}{4}$" (4) maintain present desiccant package assembly for TEM-A (5) make the purging adapter to fit TEM-A and SAD interchangeably.

46. We have found this desiccant package with its indication in the far end from the absorbent material to be rather slow at indicating a change in moisture. We will, therefore, investigate the availability of a simple paper unit to be put outside the desiccant package and next to the window for quick indication of humidity. The desiccant package would then really be depended upon to keep down the moisture until the desiccant unit could be replaced, and purged with dry nitrogen.

47. A number of things have been done in connection with Project #163 for the TEM-A as indicated below:

48. New, smaller wires have been placed in the unit for the connections from the top printed circuits to the connecting plug and to the bottom of printed circuit. This will improve flexibility and reduce the likelihood of breaking wires when the unit is taken apart for study or correction of adjustments.

49. Some problems have been experienced due to moisture and dirt. The TEM-A unit has been disassembled and our latest findings in connection with proper plating of plungers and plunger stops applied to all parts. Mating surfaces were reground and protective plating applied such that no trouble should be experienced in service.

50. Everything was cleaned while it was disassembled. All printed circuits were polished by powder polishing---then cleaned with trichlorethylene, alcohol, and dry wiping.

51. Experimental work was done on encapsulation but as mentioned in a previous paragraph this is to be abandoned.

52. A carrying case for this unit has been ordered and will be delivered with it. It consists of a wooden box with hinge and clasp assembly. It is large enough to provide foam mounting for shock protection to the unit and will, in addition, carry the mating plug, two desiccant charge units, two nitrogen bottles, and either a tube or a small salve can of meterial for sealing the threads of the nitrogen bottle when it is screwed into the adapter, and the adapter itself.

53. It has been agreed that we will test all 160 units at normal temperature and progressively to lower temperatures so that there is a separate record for each unit of its lower temperature limit if this limit is above -30°.

54. TEM-A, Project #163, is to be delivered by Friday the first week in December. We are to advise our customer engineer approximately two weeks before this of the state of our tests and the time we expect to deliver so that evaluation tests can be arranged.

55. Our customer engineer reported that in some tests on the TEM, Project #160 delivered to them, the sweep would alternately read out one time and three times when given a sweep command. This was explained as likely being due to a change in adjustment of the sweep bridge position at its stop location. The ratchet driven by the solenoid has a gear on its shaft which drives the sweep bridge around four times for one complete revolution of the sweep ratchet which has 96 teeth. Even very nominal eccentricity of this first gear might, therefore, cause a slight difference in the position at which the sweep bridge would nominally stop. All units are adjusted here to stop in what is considered a safe position compared with other adjustments which must be met.

56. We have not experienced the type of change in adjustment which has apparently occurred here but have in previous cases noted that when a unit was first set up for test without its final adjustments we would find errors in readout which would occur in multiples of four readouts. All units are adjusted here to take out these irregularities.

57. Some units have set for as long as three weeks in storage here without any visible degraduation in adjustment when later tested. This one was apparently left with too close an adjustment or has been damaged in some way. It has been found that some units tested at normal temperature reproduced radical errors in readout at low temperature unless they have been sealed with dry nitrogen at the normal temperature. This phenomenon is explained by the development of frost on the contacts and printed circuits from the moisture which was in the air before the temperature was reduced.

58. <u>SAD electronics</u>. We have been considering further the action of the electronic package supplied by our customer with the SAD unit returned. We find the electronic package is insensitive to two or three pulses. Eventually a pulse is reached which energizes the last transistor but does not saturate it. Succeeding pulses give a step input to the solenoid and condenser combination as you saw.

59. As explained this is bad if the pulses are reasonably far apart. The phenomenon of the plateau provides the effect of partially charging the condenser so that when later the transistor is saturated the new energy transferred thru the partially charged condenser is a great deal less than would be provided thru the uncharged condenser. In our study, we found as high as 5 plateaus of this sort before the output transistor was sufficiently saturated to provide full output.

60. From this we might assume that if we were to provide a number of pulses which were so close together that there was not any appreciable charging of the condenser in the first pulses required to get up to a saturation point, we should get operation. We find that this is in fact true, and that the unit we have works quite satisfactorily at 1000 cycles. (This is not a limit, merely one positive value)

61. It appears, therefore, that this type of electronic unit will operate the solenoid under certain conditions of pulses but not others, the differences resulting from the fact that the resistor-condenser combination was not sufficiently considered in designing the unit.

62. We replaced the hack and hack back-up spring in the unit left with us and have taken considerable care in obtaining the minimum possible adjustments. This results in a stroke for the solenoid of only .010" with a contact closure of approximately .005". The result of this is an operative value so low that this unit now works on the electronic unit supplied at a value somewhat below 6 volts at normal temperature and -30°C.

63. We will attempt to adjust new units to work as low as this one.